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Engineering Education in the United States

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A MAJOR FACTOR in the great industrial and technological development which has given the United States its high standard of living has been the existence and the steady growth and improvement of a system of engineering education, which has prepared students to translate scientific discoveries into practical, economical structures, machines, and processes. The present system of engineering education has been developed principally during the last 100 years, during which time the engineering applications of science to practical problems have resulted in more new developments than in all recorded prior history.

These applications of engineering to industry and public works have made great contributions to the economy and welfare of the Nation. They have also indicated the need for further research, which has resulted in new discoveries, which in turn have led to new engineering applications. In all these developments education plays a prominent part, since it supplies the trained persons to do the research, to develop the new processes, and to apply them to practical problems.

Evolution and Functions of Engineering

Engineering is broadly defined as the art and science of controlling and directing the materials and forces of nature for the use and convenience of man. It is as old as civilization, since one of the bases of modern civilization is the realization that the laws of nature cannot be changed by argument or bluster, but that man can learn those laws and can *plan ingenious methods* of utilizing them. "Engineering" is derived in part from the same stem as "ingenious." The engineer is a man of ingenuity.

In the Middle Ages men practiced engineering, utilizing such "machines" as rollers, levers, and inclined planes. Their talents were used chiefly in military activities, but they understood the theory and practice of building arches, the science of mechanics, and many of its applications to peace as well as to war. They were restricted in their sources of power largely to human muscles, with some use of animal power, and a limited direct use of water power. Nevertheless, many of their structures have survived centuries of use.

The industrial revolution, which might well be called an engineering revolution, brought on by inventions such as the steam engine, the spinning jenny, and the cotton gin, created needs for well-

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trained men in much larger numbers and with greater breadth of training than could be produced under the apprentice system. This need led to the establishment, first in Europe and later in America, of schools to train engineers. These schools developed from those which had been training military engineers. Since from the start they have provided a professional type of education, engineering has developed into a profession rather than a trade.

Definition of Professional Engineer

The model registration law, endorsed by 13 of the principal national engineering organizations, defines a professional engineer as one who applies the mathematical and physical sciences and the principles and methods of engineering analysis and design to professional or creative work in the investigation, evaluation, planning, design, and supervision of construction of structures, machines, equipment, or processes.

This definition excludes many groups popularly designated "engineers," but actually composed of technicians engaged in crafts, trades, or occupations such as engine and machine operators, technical assistants, and maintenance men. These technicians can be qualified for their work by much shorter and more elementary training programs than professional engineers can be.

The fields of specialization for engineers now recognized by accreditation are: aeronautical, agricultural, architectural, ceramic, chemical, civil, electrical, engineering mechanics, engineering physics, general engineering, geological, geophysical, industrial, mechanical, metallurgical, mining, naval architecture and marine, petroleum, process, sanitary, and textile.

Within any one of these fields engineers may be classified according to the functions they perform, among which the more important are: research, product development, design, manufacture, construction, operation, service, quality control, management, sales, consulting, and teaching.

There is a growing tendency for industry to draw on the engineering profession not only for men to perform engineering functions, but also for men to serve in managerial capacities. Many engineers are found to be peculiarly qualified for such positions due to their training in exercising judgment, in weighing all the factors in a problem, and in combining consideration of technical requirements with human factors.

A study was made in 1947 of the academic backgrounds of the presidents of 150 large American corporations, which constituted a good cross section of American industry and included many industries not essentially engineering in nature. The study showed that 33 percent of the presidents were graduates of engineering colleges; 30 percent of liberal arts and teachers colleges; 17 percent of all other types of colleges; and 20 percent had received no college education. The report stated that the proportion of engineers had increased greatly during the years just before the study was made, It probably has continued to increase, not only for presidents, but also for other administrative officers.

Supply and Demand

Engineering is the Nation's largest technical profession and one of its fastest growing fields of work. The Bureau of Labor Statistics has estimated that the profession has grown from about 40,000 in 1900 to 130,000 in 1920; 260,000 in 1940; and about 400,000 in 1950. This represents a tenfold expansion in the profession over the last half century, and an expansion of about 66 percent since 1940.

Data on the number of engineers in the various subdivisions of the profession are not very reliable, partly because engineers can easily change from one to another. However, a reasonably good idea of the

Table 1.—Number of undergraduate degrees in engineering education in 1940–41 and 1950–51

Branch of Engineering	Undergraduate degrees	
	1940–41	1950–51
Aeronautical	435	1,271
Agricultural	156	650
Architectural	185	1,141
Ceramic	83	258
Chemical	2,398	3,756
Civil and sanitary	1,430	7,136
Electrical	2,467	9,385
General	429	1,031
Industrial	552	2,583
Mechanical	3,618	10,752
Metallurgical	451	802
Mining	313	493
Naval architecture	95	128
Petroleum	362	893
Others	173	1,614
Total	13,147	41,893

growth of the various branches can be obtained from table 1.

Not only has the number of engineers been rapidly increasing, but the ratio of engineers to total industrial workers has also been steadily rising. In 1900 there was 1 engineer to about 255 workers; in 1950 1 engineer to about 65 workers. With the rapidly increasing complexity of modern technology, there is every reason to believe that this trend will continue for some time to come.

The Bureau of Labor Statistics estimates that the average annual number of graduate engineers needed under the present conditions of partial mobilization is about 30,000. The immediate need, during the "tooling-up" period, is much greater. In contrast to this need the available supply, based on 1951 enrollments, is for 1953 about 24,000, for 1954 about 19,000, and for 1955 about 23,000, with little increase over this figure in sight for several years. Thus, there seems no immediate prospect of meeting the current acute shortage of engineers.

Registration of Engineers

Registration of engineers, the legality of which is based on the power of the State to protect life, health, safety, and property, started in Wyoming in 1907. Registration laws have now been passed in all the States, the District of Columbia, and the Territories of Hawaii, Puerto Rico, and Alaska.

Engineering registration laws are not uniform, due to local conditions, date of enactment, etc. Most State laws, however, require either graduation from an accredited engineering curriculum, a written engineering examination, adequate and satisfactory engineering experience, or a combination of these. In general, registration is required of engineers who sign plans, contracts, and specifications, or who are responsible for the conduct of engineering operations. Engineers in subordinate positions, in general, are not required to register, though many do.

Professional Engineering Societies and Journals

The growth in numbers and in diversification of the engineering profession is indicated roughly by the growth in the number of national engineering societies. The American Society of Civil Engineers was founded in 1852, and was the first national professional engineering society in the United States. "Civil," a contraction of "civilian," was used to distinguish its members from military engineers. Its centennial was celebrated in the summer of 1952 in Chicago at the Centennial of Engineering, in which it was joined by many other engineering societies. The other "founder societies" were organized as follows: Mining Engineers (1871); Mechanical Engineers (1880); Electrical Engineers (1884); and Chemical Engineers (1908). Metallurgical Engineers were added to the Mining Engineers in 1919.

There are now 70 or more national engineering societies in the United States, about 30 of which maintain technical journals. In addition to the national societies, there are many local societies and branches of the national societies.

Development of American Engineering Education

The first school of technology in any English-speaking country was the United States Military Academy at West Point, established in 1802. Early American civilian engineering schools included Norwich University, founded in 1819; Rensselaer Polytechnic Institute in 1824; and the engineering schools in Union College in 1845; Harvard University, Yale University, and the University of Michigan in 1847; Dartmouth College in 1851; and New York University in 1854.

In 1862 the Congress passed the first Morrill Act, setting aside public lands for the establishment and support of colleges of agriculture and the mechanic arts. The colleges instituted under this Act, which are known as the land-grant colleges, contained schools of engineering, and their establishment gave an impetus to the development of similar schools in private institutions and non-land-grant State universities. The number of engineering schools in operation had increased to 85 by 1880, and to more than 100 in 1893 when the world's Columbian Exposition was held. At this exposition the Society for the Promotion of Engineering Education (SPEE) was organized as Section E of the World's Engineering Congress. In 1945 the society became the American Society for Engineering Education (ASEE). The number of engineering schools has continued to increase, to 147 in 1940, and to 192 in 1951, of which 149 are accredited in at least one curriculum by the Engineers' Council for Professional Development (ECPD).

Surveys and Studies of Engineering Education

In 1907, SPEE invited the "founder societies" in engineering and the American Chemical Society to join it in a study of engineering education and of the desirable degree of cooperation and unity between

engineering schools. The following year the Carnegie Foundation for the Advancement of Teaching and the General Education Board were invited to participate. This study led to the report by C. R. Mann published in 1918, under the title *A Study of Engineering Education*, by the Carnegie Foundation for the Advancement of Teaching. The report indicated a need for a more detailed investigation of the objectives of engineering education and the adequacy of the curriculums.

A study of practice and opinions in 150 cooperating colleges, in which committees including over 700 persons participated, during the years 1923–29, under the directorship of W. E. Wickenden, resulted in a two-volume *Report of the Investigation of Engineering Education*, published in 1930 and 1934, and commonly called the "Wickenden Report." This report guided engineering education through the postwar years of the 1920's and the depression of the 1930's, and is still a source of information and inspiration to engineering educators.

In 1938, through a grant by the Carnegie Foundation for the Advancement of Teaching, a detailed, analytical study was made under the direction of D. C. Jackson of factual material on nearly all aspects and conditions of engineering education in the United States. This material had been accumulated by the Committee on Engineering Schools of ECPD in surveying 679 engineering curriculums in 136 institutions from 1935 to 1938. Dr. Jackson's report, *Present Status and Trends of Engineering Education in the United States*, was published by ECPD in 1939. This report has been useful to all interested in engineering education since that time.

Two significant committee reports published in the *Journal of Engineering Education* of ASEE have had considerable effect upon other studies of engineering education. These were the reports of (1) the Committee on Aims and Scope of Engineering Curricula, published in 1940; and (2) the Committee on Engineering Education After the War, published in 1944. Both committees conceived of engineering education as comprised of two major divisions, the scientific-technological and the humanistic-social. They recommended (1) that each division consist of a designed sequence of courses throughout the four undergraduate years, (2) that increased emphasis be given to the humanistic-social division and to basic science, and (3) that some of the advanced technical subject matter be transferred to the postgraduate years.

The latter report advocated that plans be laid for the instruction of three major groups of students: (1) those who would follow the usual pattern of engineering programs and would constitute the majority of undergraduate engineering students; (2) those preparing for careers in the operation and management of industry; and (3) those who give evidence that completion of graduate courses will fit them for unusual scientific and creative accomplishments.

In 1949 ASEE appointed a committee to study methods of improving engineering teaching. This committee followed the procedure of the Wickenden study in that institutional committees were set up in 150 engineering colleges, and the report of the main committee was drawn in large part from reports of these institutional committees. The report was published in 1952 in the *Journal of Engineering Education*. The Committee felt that the most valuable feature of its work was not its report but the participation of between 1,000 and 1,500 teachers in 150 institutions in the studies which led to the report.

The American Society for Engineering Education

ASEE unites persons interested in education in all fields of engineering. It includes the Engineering College Research Council; the Engineering College Administrative Council; institutional members of several grades, comprising engineering colleges, industries, research institutes, and the like; and individual members, who may be any persons interested in engineering education. It operates through Nation-wide subject-matter divisions, national committees, and regional sections composed of all members in the region.

This society has led in all major developments in engineering education. Its *Journal of Engineering Education* (established in 1910) and other publications have won world-wide acceptance as reliable sources of information on the history of engineering education and its current problems. Its Manpower Committee antedates by 3 years the Engineering Manpower Commission.

Accreditation

By 1932 the growth in the number of engineers and engineering societies, and the increasing proportion of college graduates among them, led to a recognition of the need for setting up criteria for qualifications for membership in the societies and for a better coordination of their activities directed toward the professional advancement of the engineer.

There was also need for at least a reasonable degree of uniformity in the accrediting procedures being set up under the State licensing laws for engineers, which were being adopted by many States. At the time 135 institutions were offering degrees in engineering. Among them were wide differences in educational standards, curriculums, qualifications of faculty members, and adequacy of facilities.

To meet these needs the six societies which had participated in the Joint Committee on Engineering Education in 1907, together with the Engineering Institute of Canada and the National Council of State Boards of Engineering Examiners, established ECPD "To coordinate and promote efforts and aspirations directed toward the higher professional standards of education and practice, greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems." ECPD is composed of three representatives from each of the eight societies mentioned above. Engineering education has always been one of its major concerns and still is. The Committee on Education (originally the Committee on Engineering Schools) recommends to ECPD the accreditation of engineering curriculums. The committee made its first recommendation in 1937. At that time ECPD accredited 374 curriculums for a limited time, and 71 provisionally, in a total of 107 of the 129 institutions which had been visited by inspection teams. This committee has continued its activities, and as of September 1952 ECPD had fully or provisionally accredited 686 curriculums and 79 options in 149 institutions.

A résumé of the basic principles observed by ECPD in the accrediting process follows: (1) Accreditation is given to specific curriculums rather than to institutions as a whole, because of the variety of equipment and of faculty experience desirable in various fields of engineering. (2) To date only undergraduate curriculums have been accredited, although the desirability of accrediting graduate curriculums has been studied. (3) The purpose of accreditation, which applies only to curriculums leading to degrees, is to identify those institutions which offer professional curriculums in engineering worthy of recognition as such. (4) Inspection is made only upon the invitation of an institution. (5) Accreditation is based upon both qualitative and quantitative criteria, but no hard and fast standards have been formulated by ECPD. Rather, accreditation is based upon the over-all judgment of a qualified inspection committee which applies general criteria published in each annual report of ECPD.

ECPD originally intended to recognize only the 6 major curriculums, but pressure from the colleges and from the profession itself forced it to recognize additional curriculums, so that the first report recognized 14 different curriculums. ECPD committees have continued to resist the proliferation of curriculums, but the 1952 report lists accredited curriculums in each of the 21 fields mentioned earlier, and applications are pending before the committee for the recognition of 15 new curriculums.

Types of Schools

The baccalaureate degree in engineering is conferred by 192 institutions, of which 85 are controlled by State governments; 13 by national, territorial, or city governments; and 22 by 6 different church organizations; while 66 are private, nonsectarian institutions, and 6 institutions represent combinations of 2 of these classifications. In 155 institutions the engineering school forms a part of a college or university organization, while in 37 it is in a separately administered institution.

In 35 institutions, including 18 accredited by ECPD, the "cooperative plan" of engineering education is utilized for some or all students. This plan, inaugurated in 1906 at the University of Cincinnati, is defined as "An integration of classroom work and practical industrial experience in an organized program under which students alternate periods of attendance at college with periods of employment in industry, business, or government." The cooperative plan in nearly all cases requires 5 years for completion of an undergraduate curriculum.

Fifteen engineering colleges which do not operate on the cooperative plan require 5 years for the completion of an undergraduate curriculum in one or more fields. These curriculums in most cases have been lengthened to allow for the inclusion of more humanistic-social studies. All the other institutions, except in the cooperative plan curriculums, require 4 years.

Evening engineering education programs are offered in 36 institutions, principally for the benefit of persons employed during the daytime. The total enrollment in these programs in the fall of 1951 was 17,800, compared to 3,500 in 1924. Students may obtain bachelors' degrees in some of these programs in from 6 to 8 years, and such programs have been accredited by ECPD in 6 institutions.

Enrollments

Table 2 traces the history of undergraduate and graduate engineering enrollments and degrees from 1860 to 1951. Steady growth is indicated up to 1940, followed by a severe drop during World War II. After the war undergraduate enrollment rose sharply to an all-time high in 1947, but it has been steadily declining ever since. Undergraduate degrees reached a peak in 1950; they will continue to decline until at least 1954.

Table 2.—Engineering enrollments and degrees, 1860 to 1951

Year	Undergraduate			Graduate		
	No. of schools	Enrollments	Degrees	No. of schools	Enrollments	Degrees
1860			31			
1870		1,400	120			
1880	34		159			
1890		1,195				
1900		11,415	671			
1910		[1] 30,337	1,683			27
1920		51,908	4,400			165
1930		74,000	7,371			718
1940	147	103,270	13,808	92	4,648	1,460
1943	143	[2] 45,404	14,145	76	[2] 2,657	724
1945	136	[2] 47,150	4,060	79	[2] 3,946	515
1947	143	234,484	18,592	99	14,210	3,217
1949	180	201,927	45,200	119	17,785	5,215
1950	190	161,592	52,732	123	18,670	5,398
1951	192	145,997	41,893	124	19,640	5,742

[1] Probably includes graduate students.
[2] Civilian students only.

Source: Data collected from the 1918 report of C. R. Mann and reports of the Office of Education and of ASEE.

Graduate students in engineering were not important numerically before World War I. Following the war the rapid growth in scientific knowledge and its increasing application to engineering and technology created a need for graduate study. Graduate enrollment increased until 1940, decreased markedly during World War II, and has risen steadily since.

Preprofessional Education

Almost without exception students may enter engineering colleges directly from high school. A study conducted in 1949–51 indicates little change in admission requirements from those reported for 1924–25 in the Wickenden Report. The number of prescribed units ranged from zero in 3 institutions to 16 in one institution, with a median of 8 specified as requirements. Typical requirements for admission to engineering college are: English, 3 units; history or social studies, 1 unit; algebra, 1½ units; plane geometry, 1 unit; solid geometry, ½ unit; science (with lab. work), 1 unit; additional work in any of above-listed subjects, 3 units; other high school subjects, 4 units. Some institutions require, and all recommend, an additional one-half unit of algebra, one-half unit of trigonometry, and 1 unit of science.

There has been discussion of the desirability of requiring the completion of 2 years of college education for admission to the first year of engineering education, but no institution is known to have established this requirement up to the present time. However, a start in this direction has been made in at least 12 engineering colleges which have set up cooperative arrangements with numbers of liberal arts colleges under which a student may attend a liberal arts college for 3 years, taking programs agreed upon between the 2 institutions, and then attend the engineering school for 2 years. If his work is satisfactorily completed the student receives the bachelor of arts degree from the liberal arts school at the end of his fourth college year, and at the end of the fifth year the bachelor of science degree in engineering from the engineering school.

The rapid increase in recent years in the number of junior and community colleges has resulted in an increase in the number of students who enter engineering colleges after 2 years in a junior college or liberal arts college. A study in the Office of Education showed that in the fall of 1951, in institutions which enrolled 84 percent of the undergraduate engineering students of the country, students admitted by transfer from nonengineering curriculums constituted 5.8 percent of the sophomore class and 3.8 percent of the junior class, with individual institutions reporting as high as 47 percent of sophomores and 42 percent of juniors. The numbers of such transfers will probably increase in the future, which will make more acute a problem already facing both the engineering schools and the junior colleges.

Professional Curriculums and Degrees

Engineering curriculums are offered in all of the 21 fields previously listed, and in several others which have not as yet received accreditation. The various engineering curriculums differ from one another chiefly in the specialized subjects studied during the last 2 years. In most institutions the freshman year is the same for all fields of engineering,

and there are no radical differences in the freshman year in any of the accredited institutions. Generally a large part of the work in the sophomore year is common to all curriculums. The specialization, which begins in a limited way in the sophomore year, is intensified in the junior year and continues through the senior year.

Engineering curriculums are designed to give the student a solid foundation in the basic sciences of mathematics, physics, and chemistry, which underlie all fields of engineering, and in such fundamental engineering subjects as drawing, surveying, and mechanics. Sufficient humanistic-social studies are included to enable the graduate to take his place as a citizen and to understand the social, moral, and political implications of his technical work. Some study of fields of engineering related to his own specialty helps him to understand the interrelations of the different fields. And finally he studies some of the specialized applications of basic science and general engineering to his own special field of engineering, so that he will understand the general method of attack on problems in his field and be able to adapt himself to a variety of situations.

The interdependence and interrelations of the various fields of engineering are exemplified by the ease with which engineers educated in one branch of engineering are able to work in other fields. There is a growing tendency in industry to be little concerned with which particular branch of engineering a student has followed, so long as he has had a sound foundation in basic science and engineering.

Graduate Study Leading to Advanced Degrees

Of the 192 institutions which conferred bachelor's degrees in engineering in 1951, 124 institutions conferred 5,156 master's degrees in engineering, and 65 institutions conferred 586 earned doctorates. ECPD has not yet accredited graduate curriculums. Programs of graduate students are designed to meet individual requirements, and it is doubtful whether any standard curriculums can be organized in such a highly specialized field. A master's degree ordinarily requires at least 1 year of full-time study beyond a bachelor's degree, and the doctorate requires 3 or more years of graduate study and a dissertation. With the growing need of industry for persons with advanced training in engineering and science, it seems likely that the enrollments and numbers of degrees granted at these levels will continue to increase.

Post-College Education Not Leading to Advanced Degrees

Industrial processes have become so complicated in recent years that many industries and governmental agencies, particularly the larger and more complex ones, are finding it desirable to give young engineers special training applicable to the processes and products of the particular industry. Such training is given in a number of different ways, including apprentice courses, granting of time for graduate study in colleges, and the conduct of special courses by older and more experienced engineers in the company. Some of this post-college training results in credit toward degrees, but much of it does not.

Current Educational Problems

A few of the problems of engineering educators are outlined in the following paragraphs. No attempt has been made to cover all educational problems in engineering, nor to supply the answers to the problems. Members of engineering faculties, individually, as faculty groups, and through ASEE are working on all of these problems, many of which have no single final answer, but instead call for continued study by members of the profession.

Admission requirements.—As previously pointed out, a wide variation exists among engineering colleges in the high school subjects required for admission. Engineering is based upon mathematics and the physical sciences, and an interest in and an aptitude for these fields is an important indicator of success in the profession. However, many studies have indicated that the pattern of high school subjects bears little, if any, relationship to success in an engineering college. General quality of high school work seems to be a much better indicator of success in college than the pattern of subjects studied. Beyond a sound preparation in basic mathematics which is essential as a foundation for college mathematics, there seems little point in a student taking a full scientific program in high school. There are a growing number of engineering schools which advise the high school student to build a balanced background of general knowledge, and to make a careful study of his individual interests and aptitudes. Such schools generally make their admission requirements flexible enough so that a capable student may enroll even though his interest in engineering develops late in his high school course.

There is need for a thorough-going study of the

significance of patterns of high school subjects, of the articulation between subject matter required for admission and courses taught in college, and of the desirability of giving more consideration to the general mental ability of a prospective student, with the possibility of waiving certain subject-matter requirements for students of high mental ability.

Selection of students.—It has been estimated that the ratio of engineers to total population has reached its maximum, and that the need for engineers in the future will rise at a more rapid rate than the supply. This estimate, which is probably basically sound, the present shortage of engineers, and the high cost of engineering education, stress the need for early identification of high school students who are qualified by aptitude and ability to profitably pursue an engineering education, of encouraging such students to enroll, and of making it possible for them to do so. This calls for a high degree of cooperation between the engineering colleges and the high schools, not in a program of recruitment as such, but in an effort to see to it that young people are made aware of their own abilities and interests and of opportunities open to them in the light of these abilities and interests. It calls for the development of testing programs, both of aptitude and ability. It calls for scholarships such as those sponsored by the Science Talent Search and other programs, and invites serious consideration of a program of undergraduate Federal scholarships. Closely associated are the problems of improving high school programs and the teaching of high school subjects, so that qualified students may secure the proper foundation for the study of engineering. Some attention has already been given to the problem of making high school teaching in science and mathematics attractive enough, financially and otherwise, to induce well-qualified persons to teach these important foundation subjects.

The curriculum.—The ECPD Committee on Engineering Schools stated in its annual report for 1950 that the objective of an engineering education is to furnish the technical background and general training for the process of analysis and synthesis essential to "designing," using the word in broad terms, involving the development within the student of original, resourceful, creative ability. An ASEE committee stated in 1952 that the objective of engineering education should be to give the engineer adequate training in those subjects which are least likely to become obsolete, and which will support a growing professional career years after leaving school.

ASEE in 1952 appointed a Committee on Evaluation of Engineering Education, which has been organized and is using the same general pattern of institutional committees followed in the Wickenden study, previously mentioned. The institutional committees are asked to examine present programs and to study the needs of engineering education over the next 25 years. The institutional committees will need to concern themselves with some of the following problems.

Specialization in undergraduate engineering education has, in the opinion of many, gone too far. They believe that the common core of engineering curriculums, the basic applications of science and mathematics, should be extended. One engineering dean recommends a core curriculum covering all but 7 credit hours of the first 3 years, followed by a fourth year in which the student chooses between the professional or the terminal stem of the engineering curriculum. In either case, he is to receive the undesignated degree of bachelor of engineering. Those following the professional stem would anticipate a fifth year, leading to the designated degree (CE, ME, etc.). A graduate dean would recognize only two kinds of engineering, physical and chemical, with the possibility that physical engineering might upon further study be divided into two parts, one based on electricity and magnetism, the other on mechanics and heat.

The humanistic-social content of engineering curriculums has long been a subject of much concern to engineering educators. Many studies have been made by individual institutions and by committees of ASEE, and many articles on it have appeared in the *Journal of Engineering Education.* Although some opposition has been expressed, many engineering educators believe that the recommendations of the Committee on Education After the War (1944, previously mentioned) are sound, and should, in general, be followed. Several institutions have adjusted their curriculums in accordance with these recommendations, and others are considering such adjustment.

The basic science content of engineering curriculums also needs study. While it is impossible to foresee exactly what techniques will be in use by engineers 25 years from now, it is certain that these techniques will be based upon principles now available in the basic sciences. It is also safe to conclude

that the problems facing engineers will continue to increase in difficulty and will require a more and more fundamental approach. It is therefore apparent that the basic science content of engineering curriculums should be strengthened.

The problems outlined above have naturally led to consideration of the addition of a fifth year to the normal engineering curriculum. The 15 institutions which have adopted one or more 5-year curriculums constitute only 8 percent of the engineering colleges, and general sentiment favors continuing the 4-year curriculum for most engineers, with graduate work for the small number who wish to study further.

The cooperative plan.—Reference has already been made to the cooperative plan, which is regarded as successful by most of the institutions using it. The plan, when properly organized and efficiently administered, has advantages to the student, to the institution, and to the employer. Many engineering colleges have been deterred from using the cooperative plan because of its greater cost, the increased length of time required to receive a degree, the difficulty of finding suitable student employment in depression periods, and possible complications with labor unions. However, under proper local conditions the plan has great possibilities, and might well be seriously considered by more institutions. A program of evening instruction may to a certain extent fulfill some of the objectives of a cooperative program, but the length of time for a degree is greater in this method than in the cooperative system.

Articulation with the junior college.—The rapid growth in the number and size of junior colleges and community colleges will increase the problems of the engineering colleges in absorbing graduates of these institutions into engineering curriculums. Problems arise in the transfer of these students to engineering colleges because (1) most junior colleges require for graduation less than half as many semester hours as do engineering colleges; (2) few junior colleges can afford to offer the specialized engineering courses which are required in the first 2 years of the usual engineering curriculum; and (3) junior college courses in mathematics, chemistry, and physics are apt to be qualitatively or quantitatively insufficient to give the junior college graduate an adequate preparation for the specialized courses in the last 2 years of engineering curriculums, which creates difficulties in the evaluation of credits. These problems have aroused considerable interest, and many engineering schools have taken steps to promote a better articulation with junior colleges.

Improvement of engineering teaching.—In any effort to improve education, the key factor is the teacher. This fact is recognized by the engineering education profession in many ways, among them being (1) the series of summer schools for engineering teachers which have been sponsored by ASEE since 1927, and (2) the recent report of the ASEE Committee on the Improvement of Engineering Teaching. The study from which this report stemmed was designed to bring about discussion of teaching methods and ways of learning, to consider how to prepare students to meet new situations with skill, resourcefulness, and leadership, and to develop in the student the desire to continue to learn after graduation.

Research.—The close relationship between research and teaching has long been recognized. A research program is an essential part of graduate education. It also makes faculty positions attractive to scientifically minded men and serves as a stimulus to instruction.

Research in engineering colleges on the applications of science to new developments and processes has greatly expanded during the past decade and has benefited the Nation, the institutions, and the faculty members and students involved. Such research falls into two broad categories: (*a*) Basic research conducted by faculty members and graduate students to advance knowledge—generally supported by institutional resources or grants from foundations; and (*b*) that sponsored by Government agencies or private industries.

The recent expansion of sponsored research has brought problems to the colleges, among them being: (*a*) The danger that too large a proportion of the time of good teachers may be assigned to research projects; and (*b*) the tendency to restrict research to projects of interest to a given agency or company, to the detriment of more basic or fundamental research, generally considered the proper province of the colleges.

There is a need for engineering colleges to convince industry that its support of truly basic research is warranted on a much larger scale than heretofore.

Technical institutes.—The engineering profession has long recognized the importance of an adequate number of well-trained subprofessional personnel who, serving as engineering aides, technicians, etc., can relieve engineers of much of the technical detail

associated with their work, leaving them free for the strictly professional aspects. The Wickenden survey of 1923–29, and many studies since, have indicated the need in industry of from three to five such persons for every professionally trained engineer. However, the number of persons being trained at this level is even smaller than the number being trained for work as professional engineers.

Recognition of the need for technical institutes has been indicated by the establishment of a Division of Technical Institutes in ASEE, and by the accreditation by ECPD of 66 technical institute programs in 23 institutions. This accreditation is based to a degree upon the criteria for engineering colleges, but with due allowance for the different type of curriculums and objectives. There is need for much further study of this type of education, and for clear enunciation of policies with respect to the relationships which should exist between technical institutes and engineering colleges, and the degree of articulation which should exist among their curriculums.

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Association for Higher Education

THE ASSOCIATION FOR HIGHER EDUCATION, which until recently was known as the Department of Higher Education, is the college and university branch of the National Education Association. The adoption of the new name does not affect the status of the department in the NEA, nor the basis of membership in the association but rather is designed to suggest more specifically its broad purposes.

Representatives of higher education assisted in the founding of the NEA nearly a century ago, and the Department of Higher Education was one of the four original NEA departments or branches. By vote of the NEA Board of Directors, the department was discontinued in 1924, but was reactivated in 1942, when it became apparent that the problems of education in the postwar world would require the cooperative efforts of all those in both our schools and colleges.

Beginning with a small charter membership of several hundred, the membership now numbers some 17,500 in over 1,500 of the Nation's institutions of higher education. The Association membership

includes faculty and administrative staff members in all departments and fields of the various colleges and universities in all sections of the country, in all territories of the United States, and in nine foreign countries, as well as those whose major professional activity is closely related to higher education.

As a self-governing department of the NEA, with its own constitution, officers, and activities, the association's program and policies are determined by its members in the colleges and universities. The objectives of the association are: To promote the cause of higher education in the United States; advance the welfare of those professionally engaged in college and university work; provide opportunities for faculties throughout the Nation to work together on their common problems; promote professional fellowship among faculty members and administrators in all branches of American higher education; bring about closer cooperation among all branches of the profession of education in the United States; provide a broad program of professional activities and services for the benefit of individual members and faculties; and give higher education a voice and a participating role in national and international affairs affecting higher education.

The department has had two executive secretaries: Ralph W. McDonald, December 1, 1944, to August 31, 1951, and Francis H. Horn, October 15, 1951, to the present.

National Teacher Examinations

THE NATIONAL TEACHER EXAMINATIONS, prepared and administered annually by Educational Testing Service, will be given at 200 testing centers throughout the United States on Saturday, February 14, 1953. A candidate may take the common examinations, which include tests in professional information, general culture, English expression, and nonverbal reasoning, and one or two of eight optional examinations designed to demonstrate mastery of subject matter to be taught. The college which a candidate is attending, or the school system in which he is seeking employment, will advise him whether he should take the National Teacher Examinations and which of the optional examinations to select.

Application forms and a bulletin of information describing registration procedure and containing sample test questions may be obtained from the Educational Testing Service, P. O. Box 592, Princeton, N. J.

Medical Education

The Council on Medical Education and Hospitals of the American Medical Association has issued its report for 1951–52. Some of the facts are stated editorially as follows:

"As predicted in previous reports, further substantial increases in the number of students admitted to medical school, in total enrollments, and in the annual number of graduates were recorded last year, with new highs being established in all three categories. No large increase of the freshman class over its present record size of 7,441 students is forecast for the coming year. As the current large freshman classes progress through medical school, however, further increases are predicted in total enrollment and in the number of graduates beyond the current record figures of 27,076 and 6,080, respectively. Indeed, it is estimated that as early as next year the medical schools will be graduating approximately 6,500 new physicians annually. This figure may be compared with the average annual production of 5,140 new physicians in the 10 years prior to World War II. To make this expansion possible, the nation already has made an additional capital investment of well over $300 million in its facilities for medical education since World War II.

"The report points out the interest in the establishment of new medical schools that prevails and refers to 13 separate programs in various stages of development, which have as their objectives the creating of new medical schools or the expansion of schools of the basic medical sciences to full four-year medical schools. Therefore, while the next year or two may see some leveling off in the number of students admitted to medical school, further substantial increases are definitely in prospect.

"For the first time in recent years there were fewer than three applicants for each available place in the freshman classes of the medical schools. When only the students applying to medical schools for the first time are counted there were fewer than two applicants for every available place. The report again presents statistics to show that contrary to the popular conception many students with B and C averages in college gain admission to medical school. In fact only 30 percent of the medical students admitted to the 1951–52 freshman class had A averages, a drop of 10 percent from the previous year.

"This year's report of the Council discusses at

length some of the major problems encountered by American students who study medicine in foreign schools. Before enrolling in foreign schools, students are strongly urged to acquire a good grasp of the language in which instruction is given and to determine from the state boards of medical licensure concerned whether the credentials they plan to secure will be acceptable in the states in which they intend to practice."

(The quotations are from the *Journal of the American Medical Association*, September 13, 1952, pp. 139–140.)

UNESCO Fellowships in Fundamental Education

THE ACUTE SHORTAGE of experts for international service in fundamental education has led UNESCO to initiate a scheme designed to give advanced training to a number of people with suitable educational and technical background and some previous experience. The training is designed to enable persons to qualify for posts in technical assistance projects and on the staff of UNESCO's Fundamental Education Centres.

This program of advanced training for international service has been started in 1952 on a modest scale. It will involve the assignment of selected individuals to work under the guidance of fully qualified experts in associated projects and institutes undertaking research or studies in fields relevant to fundamental education. Four advanced training fellowships were allotted in 1951 to carefully chosen candidates, ranging from 23 to 36 years of age, from France, India, Switzerland, and the United States. Their programs of study have been worked out on the basis of their past educational and technical experience and the specialized fields in which they eventually wish to work, and will take them to projects and institutes in Canada, India, Jamaica, Kenya, Mexico, Rhodesia, and the Sudan. The holders of these grants began their course of study with a period of 4 weeks intensive orientation in UNESCO House from August 20 to September 19, 1952, preparatory to going out into the field.

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